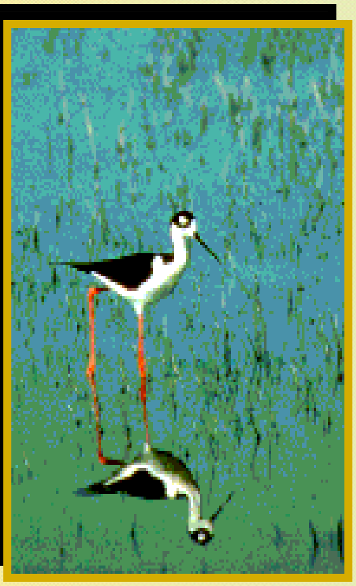

Revised Final

Executive Summary

Ecological Risk Assessment For Bolsa Chica Lowlands Project Huntington Beach, California

Prepared for
U.S. Fish and Wildlife Service
Region One

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July 2002

Contents

Executive Summary

The Bolsa Chica Lowlands are located in Orange County, California and comprise approximately 1,200 acres of estuarine, marine and upland habitat. Since the 1920s, much of the area has been used for oil and gas exploration, production, and processing. The site and adjacent areas have also been used for agriculture, cattle grazing, as a wildlife refuge, and for recreational hunting and fishing. The historical site activity as well as urban runoff draining into the Lowlands has resulted in contamination or physical disturbance of the plants, wildlife or their habitat on the site.

This Ecological Risk Assessment was conducted in anticipation of proposed clean-up and restoration of the Lowlands to a functioning estuarine system and to improve wildlife habitat. It is anticipated that once clean-up and restoration activities are complete, the site will become a state or federal wildlife refuge, as well as serving as mitigation for habitat losses elsewhere. The anticipated future use of the Lowlands served as the focus for the development of the ecological management goals for the site, which are as follows:

- Sediment, surface water quality, and food source conditions capable of supporting terrestrial, aquatic, and semi-aquatic plant and wildlife populations that would typically be found in Full Tidal and Managed Tidal coastal wetland habitats, and non-tidal Seasonal Ponds
- Sediment, surface water quality, and food source conditions supportive of individuals of special-status biota and migratory birds protected under the Migratory Bird Treaty Act likely to be found in Full Tidal and Managed Tidal coastal wetland habitats, and non-tidal Seasonal Ponds

As part of this restoration effort, the nature and extent of contamination on the site is being investigated and evaluated. Two important elements of the investigation include an:

- Ecological Risk Assessment (ERA) (this document) to evaluate contaminants present at the site at concentrations that present a risk to fish, wildlife or their habitat. The ERA identifies exposure pathways and associated site-specific assessment endpoints. The ERA also characterizes the ecological effects of the contaminants of concern. This and other information and analysis in the ERA has been or will be used to (among other things): (a) assess the nature of the contamination at the site and identify the general areas of the site that contain contamination (b) assess the nature, characteristics, and sensitivities of the natural resources at the site (c) determine the extent to which the contamination threatens to impact natural resources at the site and (d) identify the types or routes of exposure to the contamination that pose an unacceptable risk; and
- Confirmatory Sampling Program (CSP) to delineate the extent of on-site contamination and the bounds of needed clean-up efforts. (The CSP was not completed at the time of publication of this report.)

Two important outcomes of the ERA are identification of (a) chemicals that will be considered for further evaluation or remediation and (b) chemicals that need not be considered any further.

Chemicals that should be retained for further evaluation or remediation are referred to as Chemicals of Ecological Concern (COECs) and are listed in Tables ES-1 to ES-3.

The results of this ERA will be used as a tool used to establish clean-up criteria for portions of the property affected by on-site contamination. It builds on previously available information about the site (including ecological and chemical characterization, as well as planned restoration), which was used to plan and conduct the current work.

Additionally, delineation of boundaries around the contaminated portions of the site will be completed as part of the future activities including through the CSP and the development of the remediation plan. It is important to note that this baseline ERA does not assess the overall areal extent of the contamination, generate or identify remediation goals or clean-up concentrations, or identify the sensitive habitat areas to be protected from disturbance. The development of clean-up goals is a complex risk management process that involves an evaluation of the information contained in the ERA and a range of other factors, such as technical feasibility and appropriate levels of risk.

In the future, the information and analysis in this baseline ERA will be used as a tool to evaluate the ecological impacts of alternative remediation strategies and establish clean-up levels that will protect the natural resources at risk. Possible interim steps also include removal of hot spots and other interim risk reduction measures.

Introduction and Project Approach (Section 1)

The ecological risks at this site were evaluated using a phased/tiered approach consistent with established methodologies, adapted to the specific needs of the Bolsa Chica project as described in the CSP/ERA Work Plan and the revised work plan for the project (CH2M HILL, 1998a and 2000). The Work Plan as well as the Scoping Assessment (CH2M HILL, 1998b) and Ecological Effects Characterization Report (CH2M HILL, 1999) outline the various phases of the ERA for the Lowlands and provide preliminary results. The project approach and content of the various reports are summarized in Section 1.2 of this report.

Specific objectives of this Final ERA Report include updating previous information in the Problem Formulation (Section 2.0) and Analysis (Section 3.0) portions of this report and conducting the final phase of the ERA (the Risk Characterization, Section 4.0) using the results of the ERA Sampling and Analyses, Focused Sampling and Analyses, and previously available information from the Phase II Environmental Assessment (Tetra Tech, 1996).

The data collected from all those investigations were analyzed and evaluated to help refine and focus the identification of ecotoxicological risk drivers at the site. The ERA uses a wide range of commonly utilized tools to evaluate the ecological risks related to site contamination. Some of these tools include site-specific toxicity tests, site-specific bioaccumulation tests, statistical analysis, a review of published literature values and several phases of on-site sampling.

The ERA report evaluates the risk that the on-site contamination poses to aquatic and terrestrial plant and animal species that currently use the site and are likely to use the site after the restoration. The report evaluates potential exposure of receptors to chemicals at the site through the development of Exposure Point Concentrations and the calculation of potential dietary exposure of birds and mammals (as doses) through the food chain uptake model. The Exposure Point Concentrations are a function of chemical concentrations detected at the site and the manner in which the receptors are exposed to the chemicals. The report also develops Reference Toxicity Values (RTVs) which are chemical concentrations in sediment, water, or dietary dosages that are expected to be associated with adverse effects on biota based on site-specific toxicity studies, site-specific bioaccumulation studies and published literature values. Finally, the ERA compares the anticipated exposure (the Exposure Point Concentration or dose) to the RTV (which is a measure of potential harm) to reach conclusions about which chemicals of potential ecological concern (COPECs) pose a risk sufficient to retain the chemical for further evaluation or remediation. Chemicals that are present at sufficiently high concentrations (typically above the RTV) are placed on the list of Chemicals of Ecological Concern or COECs. Chemicals that are not placed on the COEC list are not considered to pose an ecological risk at the site, based on available information, and are not intended to be carried forward for further analysis. A graphical representation of this approach is shown in figure ES-1.

Problem Formulation (Section 2)

The Problem Formulation section of the ERA presents information that is used to focus the evaluation of ecological risks at the site. The end product of the section is a preliminary conceptual site model for ecological risks at the site.

The ERA incorporates and relies on the extensive information already available about conditions at the site including site background, habitats found onsite, and the results of previous sampling conducted at selected locations throughout the site. This information is found in Sections 2.1 and 2.2 of this report.

Previous sampling had indicated that concentrations of a number of chemicals exceeded levels that could be expected to cause adverse effects in fish, wildlife, or their habitats. As a result, there was a need for more comprehensive sampling and evaluation of clean-up/restoration needs. The available information was reviewed to select potential ecological receptors, determine chemicals of potential ecological concern (COPECs), and identify pathways through which the receptors could be exposed to the COPECs. The receptors that were selected included aquatic and terrestrial plant and animal species that currently use the site and are likely to occur there under future conditions. COPECs identified for further evaluation were those that exceeded screening-level benchmark values (levels that could be associated with adverse effects) for sediment, water, or biological tissues. The results of these evaluations are found in detail in Sections 2.2 through 2.6 of this report.

Analysis (Section 3)

This section presents the technical evaluation of chemical and ecological data to determine potential for ecological exposure and adverse effects.

Exposure Characterization (Section 3.1)

The Exposure Characterization contains a summary of the results of the ERA Sampling and Analyses, Focused Sampling and Analysis, and Phase II Environmental Assessment (Tetra Tech, 1996). The summary identifies the different types or "suites" of analyses performed on sediment/soil, pore water, surface water, and biota tissue and whether that data was of a quality that allowed the data to be useful for purposes of the ERA (e.g. were the detection limits sufficiently low to allow for meaningful analysis). The data were evaluated for use in the ERA, subjected to a background evaluation for inorganic chemicals in sediment, and then used in the various evaluations to develop an exposure profile and stressor-response profile. These steps are described below.

Field Sampling and Analysis: The preparation of the ERA involved several different sampling investigations that were conducted throughout the Lowlands. In addition to sampling conducted in 1996 for the Phase II Environmental Assessment (Tetra Tech, 1996) and sampling conducted to characterize soil/sediment within the dredge footprint for the proposed restoration of the site (Kinnetic Laboratories/ToxScan, Inc. and CH2M HILL, 1999), we conducted two main phases of sampling and analysis specifically for the ERA. These two phases of ERA-related sampling are described below, and the results of all sampling (including the Tetra Tech investigation and the dredge-material characterization) are included in the project database that is included as Appendix D of this report.

1. **The ERA Sampling and Analyses** phase in 1998-1999 was designed to complete sampling for areas away from known or suspected sources of contamination ("random sampling" locations), to conduct toxicity bioassays and bioaccumulation studies using site-collected sediment and water from both "random" and "focused" sampling areas, and to analyze field-collected biota for chemicals that bioaccumulate.

   Random sampling of sediment was conducted by taking samples at a density of about one core per 4 acres throughout the site, but with at least one core per Cell. (The site has been divided into units called "Cells." These Cells vary in size from 1 to over 100 acres.) For Cells larger than 4 acres in size, up to six cores from contiguous areas within the Cell were composited to reduce analytical costs. Surface sediment (0- to 6-inch depth) from these cores was analyzed to evaluate potential exposure of ecological receptors. A subset of the surface sediment samples also was used for sediment bioassays (using amphipods and polychaete worms [Nereis]), and for extraction of pore water for bioassays with bivalve larvae. Subsurface sediments (18- to 24-inch and 42- to 48-inch depth intervals combined) were analyzed to determine whether buried wastes were present. To obtain sediment or pore water for conducting bioassays from the Focused Sampling locations, this sampling effort also included limited sampling from selected locations of the Focused Sampling program (such as waste sumps, pipelines, maintenance areas, and stormwater inflow areas).

2. **The Focused Sampling and Analysis** phase of the ERA occurred in 2000. The program was designed to allow for more detailed analyses of previously sampled "random" locations (sampled as part of the ERA Sampling and Analyses described previously), and to identify the nature of contamination associated with previously identified sources (such as sumps, wells, pipelines, maintenance areas, etc.) and potential sources. The "focused sampling" locations were divided into three main categories that were sampled as follows:

   a) Random Follow-up Sites: Most of the Random Follow-up sampling locations were re-sampled to a depth of 0.5 foot below ground surface (bgs). If the bottom composite sample during random sampling exceeded any of the criteria for re-sampling, samples were advanced to the original project depth of 6 feet bgs. Only those constituents that exceeded specified criteria for any particular sample were reanalyzed.

b) Previously Uncharacterized sites (Clean-up Agreement and Release [CAR] sites): Sampling of the CAR sites was conducted by taking samples at a density of one core per acre and analyzing them individually. For those CAR sites that were smaller than 1 acre, two borings were collected and were analyzed individually. However, if the CAR site was smaller than 0.1 acre, two borings were collected, the two top samples were composited together, and the two middle/bottom samples were composited together for analysis. All borings were advanced to 6 feet bgs. Samples from each boring were retrieved from three intervals: 0- to 6-inches, 30- to 36-inches, and 66- to 72-inches. The middle and bottom interval from each boring were combined into a single sample.

c) Partially Characterized sites: Sampling of the Partially Characterized sites varied from one kind of facility or feature to another. Sampling rates for all of these sites were based on the estimated area or linear length of those facilities and features. Prior to making the final decisions on sampling rates, constituent lists to use, and depths below the ground surface, all Tetra Tech and CH2M HILL data were matched to the list of facilities and features. These data were then used to determine whether any additional characterization was needed. Boring depth varied by site. Surface sediment (0 to 6-inch depth) from all Partially Characterized sites was analyzed. No compositing was conducted on any of the Partially Characterized sites.

The results of the ERA will be used to focus the future sampling at the site during implementation of the CSP. For example, the suite of analytes will be reduced from the suite used in prior sampling efforts because particular analytes are not found to be of concern to plants, animals or their habitat on the Bolsa site. In addition, the analysis of information in the ERA may allow further reductions in the COEC list due to co-locations of chemicals with other COECs or other factors. Higher detection limits for some analytes may be appropriate if higher concentrations would be sufficient to detect levels of concern.

The analytical data for soil and sediment were combined as a single exposure medium because both media will become sediment under the post-restoration habitat types for the Lowlands, and their character varies seasonally.

Evaluation Areas: The Lowlands were divided into areas with similar habitat types under current and/or post-restoration conditions for evaluation of potential risks. The specific Cells included in each area are:

- Bolsa Bay – Inner Bolsa Bay (Cell IB) and Outer Bolsa Bay (Cell OB)
- Full Tidal – Cells 1, 1A, 3 through 8, 15 through 18, 43, 44, 51, 58, 59, 61, and 62
- Future Full Tidal – Cells 14, 19 through 40, and 63
- Garden Grove – Wintersburg Flood Control Channel – Cell 52

- Gas Plant Pond Area – offsite areas down gradient from the former Gas Plant, south of Cells 11 and 12
- Muted Tidal plus Rabbit Island – Cells 41, 42, 45 through 50, 53, 55, 60, 66, and 67
- Seasonal Ponds – Cells 2, 9 through 13
- Sitewide (biota only) – terrestrial invertebrates that were composited from throughout the Lowlands

Background Evaluation: The evaluation of background levels for inorganic constituents in sediments was completed using samples collected from onsite focused and random sample locations (including those within the proposed dredge area footprint). Maximum concentrations of chemicals considered to be background levels in surface and subsurface sediments and a combined value for all sediments were estimated; this was accomplished using cumulative distribution plots in which detected and non-detected results were evaluated together and separately to distinguish the impact of non-detected results on the distribution and estimated background concentrations. Maximum background values for the combined data set were estimated for arsenic (11 mg/Kg), barium (110 mg/Kg), beryllium (0.94 mg/Kg), cadmium (0.66 mg/Kg), chromium (43 mg/Kg), cobalt (10.1 mg/Kg), copper (26.1 mg/Kg), lead (48 mg/Kg), mercury (0.28 mg/Kg), nickel (30 mg/Kg), selenium (0.54 mg/Kg), silver (0.22 mg/Kg), thallium (0.61 mg/Kg), vanadium (75 mg/Kg), and zinc (103 mg/Kg).

Exposure Analysis and Exposure Profile: The exposure profile established a relationship between stressors and potential receptors through: (1) identification of potential sources of chemical stressors (the COPECs) and their spatial distribution across the site, (2) calculation of exposure point concentrations for various exposure media and receptors based on the most likely exposure scenario for each species, and (3) calculation of reasonable maximum daily dosages for chemical intake through the food chain from abiotic and biotic sources by terrestrial and semi-aquatic birds and terrestrial mammals.

Sources: The primary sources of COPECs include oil and gas production, non-point source pollution, and historic farming and hunting activities on or near the site.

Exposure Point Concentrations: A conservative approach was used to define the exposure point concentrations for receptors in the Bolsa Chica Lowlands. The exposure point concentrations for abiotic media (intake or contact with sediment/soil, surface water, and pore water) were calculated based on the mobility of the receptor being evaluated. For sedentary organisms such as plants and invertebrates, the exposure was based on the maximum detected concentrations for each detected chemical in each evaluation area. In contrast, for the mobile receptors such as birds and mammals, the exposure point concentrations were based on the 95th percent upper confidence limits (UCLs) of the arithmetic mean. (If a 95th UCL could not be calculated, the maximum detected concentration was used.)

Exposure point concentrations for the biota component of the diets for terrestrial and semi-aquatic birds and terrestrial mammals were calculated based on tissue samples collected throughout each of the evaluation areas. This combination of tissue data was used primarily because the mobile higher trophic level receptors are not limited to foraging within a single cell and may forage throughout the site. Tissue concentrations for field-collected terrestrial plants, terrestrial invertebrates, bird eggs, small mammals, and fish were combined based on tissue type. A 95th percent UCL of the arithmetic mean was then calculated for the combined tissue group. However, different species of field-collected aquatic invertebrates were not combined because different representative species would not feed on all the aquatic invertebrates collected. The exposure point concentration for each aquatic invertebrate species was either the 95th percent UCL of the arithmetic mean or the maximum detected value, following the same rules as were applied to the other exposure media.

The use of maximum exposure concentrations as described above was carefully considered along with the less conservative alternative approach of using the 95th percent UCL of the mean. The selected approach is consistent with standard practice. Plants and invertebrates are immobile or relatively sedentary receptors – it is not reasonable to assume that they spatially average their exposure over the medium in which they reside (Suter *et al.* 2000). To determine which chemicals at the site may require clean-up, the maximum concentration is the most appropriate exposure measure. This approach is particularly appropriate at this site because the site is intended to serve as mitigation habitat, and because it will become a wildlife refuge once remediation is complete.

Food chain uptake or exposure: Contact with chemical stressors by various receptors must take into account various exposure areas and pathways. Exposure point concentrations for abiotic (sediment/soil and surface water) and biotic (field-collected plants, invertebrates, bird eggs, small mammals, and fish) exposure media were calculated based on the most likely exposure area and pathways for selected representative species. These species and pathways include:

- Terrestrial plants - Direct contact via root uptake from sediment/soil
- Terrestrial invertebrates - Direct contact with and ingestion of sediment/soil
- Belding's savannah sparrow - Ingestion of terrestrial plants, terrestrial invertebrates, and sediment/soil, and surface water
- American kestrel - Ingestion of terrestrial invertebrates, small mammals, and sediment/soil, and surface water
- Black-necked stilt - Ingestion of aquatic invertebrates, sediment/soil, and surface water
- Least tern - Ingestion of fish, sediment/soil, and surface water
- Black-crowned night-heron - Ingestion of aquatic invertebrates, fish, small mammals, sediment/soil, and surface water
- Western harvest mouse - Ingestion of terrestrial plants, invertebrates, sediment/soil, and surface water
- Coyote - Ingestion of terrestrial plants, bird eggs, small mammals, sediment/soil, and surface water
- Aquatic plants – Direct contact via root uptake from sediment/soil and surface water
- Aquatic macroinvertebrates - Direct contact with and ingestion of sediments/soil
- Fish - Direct contact with surface water

Reasonable maximum daily dosages were calculated for intake of the exposure media mentioned above by terrestrial and semi-aquatic birds and terrestrial mammals.

Ecological Effects Characterization (Section 3.2)

The Ecological Effects Characterization focused on (1) evaluating site-specific effects data to determine the potential adverse effects that may result from different concentrations of chemical stressors, and (2) establishing a link between these effects and the assessment endpoints and ecological conceptual site model. The product of this portion of the ERA was the stressor-response profile that was combined with the exposure profile (described above) to conduct the Risk Characterization.

Site-specific effects data that were evaluated consisted primarily of toxicity and bioaccumulation bioassays. The toxicity bioassays were used to evaluate responses to the mixture of chemicals present in sediment, pore water, or surface water. The bioaccumulation bioassays were used to evaluate the potential for significant bioaccumulation of chemicals from sediment into the food chain. The results of sediment and pore water bioassays were also combined with the corresponding chemical analyses to calculate effect levels through regression analyses. Toxicological information from literature sources, toxicity databases, and wildlife toxicological reviews was also reviewed for terrestrial and semi-aquatic receptors to identify RTVs for each chemical and representative species.

The toxicity bioassays were conducted with marine amphipods and polychaete worms (sediment); bivalve larvae (pore water); freshwater (*Ceriodaphnia)* and marine *(Mysidopsis)* invertebrates, and topsmelt fish (surface water). The test species were placed in site-collected sediment, pore water, or surface water for a defined period of time that was considered to represent an acute or chronic exposure. Endpoints measured included survival and reburial for amphipods; survival of worms; survival and larval development for bivalves; survival and growth for fish; survival and reproduction for *Ceriodaphnia*; survival, growth, and fecundity for mysids. Results of the toxicity bioassays are summarized below:

- Sediment - Amphipod survival ranged from 0 to 98 percent; reburial ranged from 22 to 100 percent for those samples with surviving amphipods. Polychaete worm survival was not significantly affected in any of the tested sediments. Results were further evaluated using regression analyses (described below).

- Pore water - Bivalve larvae No Observed Effect Concentrations (NOECs) for survival and development ranged from 0.098 to 100 percent of the test sample. Lowest Observed Effects Concentrations (LOECs) for survival and development ranged from 0.2 to 100 percent sample. The EC_{50} and LC_{50} measurements ranged from 0.17 to 100 percent sample. However, many of the lower sample percentages were the maximum tested concentrations as a result of salinity adjustments that were made to bring the pore water samples into the tolerance range for the tested species. Results were also further evaluated using regression analyses (described below).

- Surface water - Topsmelt survival and growth were not significantly affected by any of the tested surface waters. *Ceriodaphnia* NOEC for survival and reproduction was 50 percent sample and the LOEC for survival and reproduction was 100 percent sample. The

Mysidopsis showed no toxic effects and the NOEC for survival, reproduction, and fecundity was 100 percent site sample.

Bioaccumulation tests were conducted using polychaete worms and site-collected sediments. The results of this testing showed that there was significant bioaccumulation for several inorganic and organic analytes, as follows:

- For inorganic analytes, significant bioaccumulation was observed for barium, cobalt, copper, lead, mercury, nickel, selenium, vanadium, and zinc.
- For pesticides and PCBs, significant bioaccumulation was observed for BHC (beta and gamma), chlordane (alpha, gamma, and technical), 4,4′-DDD, 4,4′-DDE, dieldrin, and Aroclor 1254.
- For PAHs, significant bioaccumulation was observed for acenaphthene, anthracene, chrysene, pyrene, and fluorene.

Simple linear regression analyses were performed to determine which chemicals in sediment and pore water best explained amphipod and bivalve toxicity bioassay results. The toxicity bioassay results were combined with the corresponding chemical analytical data for sediment and pore water for each test replicate to determine whether a dose-response relationship was present and to estimate site-specific survival LC_{20} and LC_{50} for amphipods exposed to sediment, and larval development EC_{20} and EC_{50} for bivalves exposed to pore water.

In addition, correlation analyses were conducted to determine whether concentrations of many chemicals were correlated with each other in sediments. It was found that chemicals tended to occur in groupings, such as metals, petroleum-related compounds, and organochlorines (pesticides and PCBs). However, concentrations of chemicals in pore water were not significantly correlated with their concentrations in the sediment from which the pore water was extracted. This lack of correlation reduces the ability to predict pore water toxicity to receptors (such as bivalve larvae) on the basis of chemical concentrations in sediment.

The stressor-response profile was the end product of the Ecological Effects Characterization. This profile established a link between receptors and potential adverse effects. Site-specific information from toxicity bioassays, bioaccumulation studies, and regression analyses, as well as literature toxicity information, were used to develop a list of reference toxicity values. These values are presented in Section 3 of this report and are summarized below:

- NOECs, No Observed Adverse Effect Level (NOAELs), LOECs, Lowest Observed Adverse Effect Levels (LOAELs) (see Acronyms and Abbreviations) and other toxicity-based endpoints – Obtained from the literature for terrestrial receptors (plants, invertebrates, birds, and mammals)
- LC_{20} and LC_{50} for survival of aquatic invertebrates in sediment – Derived from the regression analyses conducted on amphipod toxicity bioassay results
- NOECs for survival of aquatic invertebrates in sediment – Calculated from polychaete worm toxicity bioassay results
- EC_{20} and EC_{50} for larval development of aquatic invertebrates in pore water – Derived from the regression analyses conducted on bivalve toxicity bioassay results

- NOECs for survival and growth of fish in surface water – Calculated from fish toxicity bioassay results
- NOECs and/or LOECs for survival/growth, reproduction, and/or fecundity of aquatic invertebrates in surface water– Calculated from *Ceriodaphnia* and *Mysidopsis* toxicity bioassay results

Risk Characterization (Section 4)

The Risk Characterization presents the evidence linking COPECs to potential adverse effects in the Lowlands including calculation of HQs and evaluation of site-specific toxicity bioassays and bioaccumulation studies to provide a weight-of-evidence for potential risks and identify COECs. The identification of COECs is presented in Figure ES-1. All COPECs that exceeded any available RTV as well as chemicals that showed significant bioaccumulation in *Nereis* clam worms were retained as COECs. The overall risk posed by a COEC in a given medium and evaluation area was determined based on the types of RTVs that were exceeded (i.e., no-effect levels vs. low-effect levels and chronic effect levels vs. acute effect levels). The overall risk categories were defined as follows:

- Unknown – RTVs were not available, so risk could not be quantified.
- None – Exposure does not exceed any of the available RTVs.
- Uncertain – Exposure exceeds a no-effect level, but risk could not be fully quantified because a low-effect level was not available (Category U).
- Some Possible Risk – Exposure exceeds a no-effect level, but not a chronic low-effect level (Category C).
- Possible Risk – Exposure exceeds a chronic low-effect level, but not an acute effect level (Category B).
- Probable Risk – Exposure represents the highest level that could be quantified. Exposure exceeds an acute effect level or showed significant bioaccumulation in *Nereis* clam worms (Category A).

The COECs in each medium for terrestrial and aquatic receptors are presented in Tables ES-1 through ES-3. The chemicals in sediment/soil showing potential for risk to terrestrial receptors consisted of metals, PAHs, and potentially dieldrin (Table ES-1). The highest level of risk that could be quantified for terrestrial receptors was Category B (possible risk) because RTVs were limited to chronic no-effect and low-effect levels; acute RTVs were not identified.

The chemicals in sediment/soil that showed the highest potential for risk (Category A) to aquatic receptors included metals, pesticides, some PAHs, and TPH-diesel and waste oil (Table ES-2). In addition, significant bioaccumulation of metals and pesticides in *Nereis* clam-worms was observed for several evaluation areas. All COECs that also had significant bioaccumulation were considered to pose a probable risk (Category A) based on comparisons to RTVs, with the exception of lead and vanadium in the Full Tidal area. These chemicals were estimated to pose a possible risk (Category B) to aquatic receptors.

The chemicals in surface water that showed probable risk (Category A) to aquatic receptors were limited to copper and endrin as these two chemicals were the only ones that exceeded the CA-WQS acute level (Table ES-3). Possible risk (Category B) was estimated for several other metals, pesticides, and TPH-diesel and waste oil.

Conclusions and Recommendations (Section 5)

The overall conclusion to the ERA is that several chemicals pose various levels of risk to terrestrial and aquatic receptors. Most notably, metals, pesticides, PAHs, and TPH-diesel and waste oil consistently show possible (Category B) and probable (Category A) risks to receptors.

COECs identified in each area of the Lowlands are recommended for further evaluation or remediation. Clean-up goals should be developed for each COEC based on the receptors that may be at risk. Once clean-up goals are drafted, the extent of contamination exceeding clean-up goals within each area should be determined so that clean-up efforts will focus only on those areas or portions of areas that cause risk.

Table ES-1

Chemicals of Ecological Concern in Sediment/Soil - Terrestrial Receptors
Bolsa Chica Lowlands

Chemical of Ecological Concern (COEC)	Future Full Tidal	Gas Plant Pond Area[a]	Muted Tidal	Seasonal Ponds
Inorganics				
Arsenic	B	B	B	B
Barium	B	C	B	B
Beryllium	B		B	B
Cadmium	B		B	
Chromium	B	B	B	B
Cobalt	B	C	B	C
Copper	B	B	B	B
Lead	B	B	B	B
Mercury	B	B	B	B
Molybdenum	B		B	B
Nickel	B	C	B	B
Selenium	B	B	B	B
Silver	B			
Thallium	B	B	B	B
Vanadium	B	B	B	B
Zinc	B	B	B	B
Organics				
4-Nitrophenol	B			
Acenaphthene	B	B		
Acenaphthylene	B		B	
Benzo(a)anthracene	B	B	B	B
Benzo(a)pyrene	B	B	B	B
Benzo(g,h,i)perylene	B	B	B	
Chrysene	B			
Dieldrin		U		
Indeno(1,2,3-c,d)pyrene	B			
Naphthalene	B			
Phenanthrene	B			B

Notes:
[a]This area includes samples collected in the vicinity of the ponds downgradient of the former Gas Plant (outside the numbered Cells, south of Cells 11 and 12).

Risk Categories	*Description*
U	Uncertain - exposure exceeds chronic no-effect level, but a chronic low-effect level was not availa
C	Some Possible - exposure exceeds a chronic no-effect level, but not a chronic low-effect level
B	Possible - exposure exceeds a chronic low-effect level

Table ES-2

Chemicals of Ecological Concern in Sediment/Soil - Aquatic Plants and Organisms, and Semi-Aquatic Birds
Bolsa Chica Lowlands

Chemical of Ecological Concern (COEC)	Bolsa Bay	Full Tidal	Future Full Tidal	Garden Grove	Gas Plant Pond Area[a]	Muted Tidal	Seasonal Ponds
Inorganics							
Arsenic	B	B	A	B	A	A	A
Barium	B	B	B*	U	U	B	B
Beryllium	B	B	A	B	B	B	B
Cadmium	B	B	A	C	C	B	C
Chromium	B	A	A	C	A	A	A
Cobalt	B	A*	A	B	B	A	B
Copper	B	B	A*	B	B	A	B
Lead	B	B*	A*	B	B	A*	A
Mercury	B	A	A*	B	B	B	A
Molybdenum		B	B	B		B	B
Nickel	A*	A*	A	B	B	A*	A*
Selenium	A	A	A*	A	A	A	A
Silver	C	B	A	C	B	C	B
Thallium	A	A	A	A	A	A	A
Vanadium	B	B*	A*	B	B	B	B
Zinc	B	B	A*	B	B	A*	B
Organics							
4,4'-DDD	A	A	A*	A	A	A	A
4,4'-DDE	A*	A	A*	A	B	A	A*
4,4'-DDT	B	A	A			A	B
4-Methylphenol			U				
4-Nitrophenol			B				
Acenaphthene		A	A*		A		
Acenaphthylene			A			A	
Aldrin			A				
Anthracene	C	B	B			B	B
Aroclor 1254	U	U	U	U	U	U	U
Aroclor 1260		U	U		U	U	
Benzo(a)anthracene	C	B	B	C	B	B	B
Benzo(a)pyrene	B	B	B	B	B	B	B
Benzo(b)fluoranthene	B	B	B	B	B	B	B
Benzo(e)pyrene	U	U	U	U		U	U
Benzo(g,h,i)perylene	B	B	B	B	B	B	
Benzo(k)fluoranthene	U	U	U	U	U	U	U
BHC-alpha	U	U	U		U	U	U
BHC-beta	U	U	A*				U
BHC-delta		U	U	U		U	
BHC-gamma	U	U	U			U	U
Bis(2-ethylhexyl)phthalate	U	U	U	U		U	U
Butylbenzylphthalate	U	U	U	U		U	U
Chlordane (technical)	A	A	A*	A		A	
Chlordane-alpha	A	B	A*	A		A	
Chlordane-gamma	A		A*	B		A	
Chrysene	C	A	A*	C	B	B	B
Dibenz(a,h)anthracene		A	A				A
Dieldrin	B	B	A	B	B	A	B

Table ES-2, continued
Chemicals of Ecological Concern in Sediment/Soil - Aquatic Plants and Organisms, and Semi-Aquatic Birds
Bolsa Chica Lowlands

Chemical of Ecological Concern (COEC)	Bolsa Bay	Full Tidal	Future Full Tidal	Garden Grove	Gas Plant Pond Area[a]	Muted Tidal	Seasonal Ponds
Inorganics							
Dimethylphthalate	U	U	U		U	U	
Di-n-butylphthalate	U	U	U	U	U	U	U
Di-n-octylphthalate	A	A	A	B	A	A	A
Endosulfan I		U	U			U	U
Endrin		A	A			A	A
Endrin aldehyde		B	A	B		A	A
Endrin ketone		A	A			A	
Fluoranthene	C	C	B	B	C	C	B
Fluorene		A	A*		A	A	
Indeno(1,2,3-c,d)pyrene	U	U	U	U		U	
Naphthalene		A	A		A	B	
Oil and Grease	B	A	A	B	A	A	A
Phenanthrene	B	A	A	A	A	A	A
Phenol	U					U	U
Pyrene	C	B	B	C	C	C	C
TPH-Diesel	A	A	A		A	A	A
TPH-Diesel and Waste Oil	A	A	A	B	A	A	A
Waste oil	A	A	A	B	A	A	A
High MW PAHs	C	B	B	C	C	C	C
Low MW PAHs	B	A	A		A	A	
Total DDT	A	A	A	A	A	A	A
Total PAHs	B	A	A	B	A	B	B
Total PCB	B	B	A	B	A	A	B
Total phenol	U	U	U			U	
Total phthalate esters	U	U	U	U	U	U	U

Notes:
[a]This area includes samples collected in the vicinity of the ponds downgradient of the former Gas Plant (outside the numbered Cells, south of Cells 11 and 12).
*Chemical showed significant bioaccumulation in *Nereis* clam worms

Risk Categories	***Description***
U	Uncertain - exposure exceeds chronic no-effect level, but a chronic low-effect level is not available
C	Some Possible - exposure exceeds a chronic no-effect level, but not a chronic low-effect level
B	Possible - exposure exceeds a chronic low-effect level
A	Probable - exposure represents the highest-level risk that could be quantified

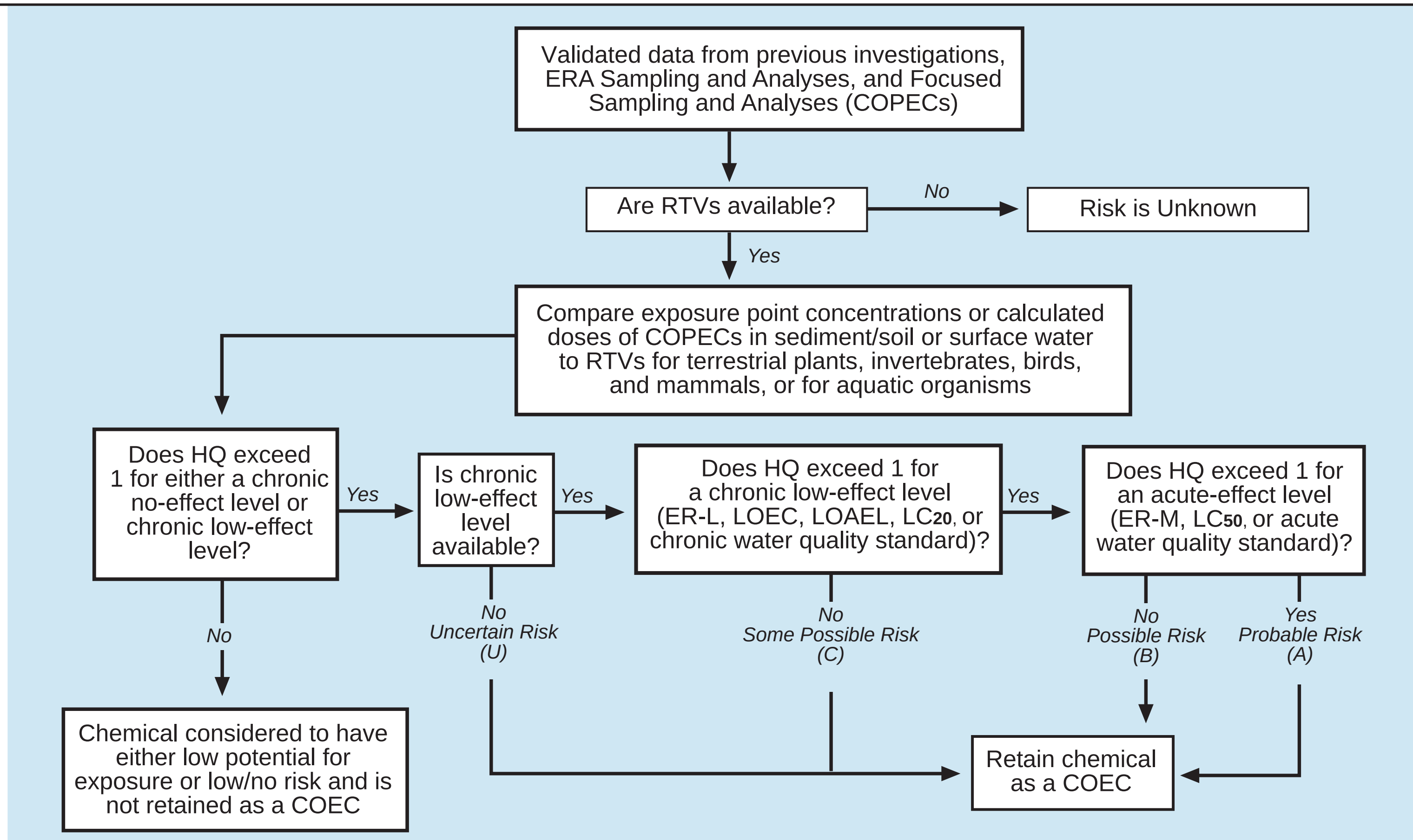
Table ES-3

Chemicals of Ecological Concern in Surface Water - Aquatic Receptors
Bolsa Chica Lowlands

Chemical of Ecological Concern (COEC)	Bolsa Bay	Full Tidal	Future Full Tidal	Garden Grove	Gas Plant Pond Area[a]	Muted Tidal	Seasonal Ponds
Inorganics							
Arsenic			B	C			
Arsenic, Dissolved	C	B	B	C			B
Barium			B	B			B
Barium, Dissolved	U	B	B	B			B
Beryllium, Dissolved		U					
Cadmium			B	B			
Cadmium, Dissolved	B	B	B	B			B
Chromium			B	C			
Chromium, Dissolved	B	B	B	B			B
Cobalt			B	B			
Cobalt, Dissolved		B	B	C			B
Copper			A	A			B
Copper, Dissolved	A	A	A	B			A
Lead			B	B			
Lead, Dissolved	C	B	B	B			B
Mercury		U	U	U			
Nickel			B	B			
Nickel, Dissolved		B	B				
Silver			B				
Silver, Dissolved	B	B	B				B
Sulfate	B	B	B	B			B
Vanadium			B	B			
Zinc			B	B			A
Zinc, Dissolved	C	C	B				B
Organics							
2,4-D			B				
4,4'-DDT			B				
4-Nitrophenol			B	B			
BHC-delta			B				
Chlorpyrifos			B				
Diazinon			B	B			B
Dicamba			B				
Dieldrin		B	B	B			
Endrin		A					
Malathion			B				
TPH-Diesel		B	B	B			B
Waste oil		B	B	B			B

Notes:
[a]This area includes samples collected in the vicinity of the ponds downgradient of the former Gas Plant (outside the numbered Cells, south of Cells 11 and 12).

Risk Categories	*Description*
U	Uncertain - exposure exceeds chronic no-effect level, but a chronic low-effect level is not available
C	Some Possible - exposure exceeds a chronic no-effect level, but not a chronic low-effect level
B	Possible - exposure exceeds a chronic low-effect level
A	Probable - exposure represents the highest-level risk that could be quantified



Risk Categories

Unknown – Because RTVs are not available, risk cannot be evaluated.

None Exposures do not exceed any available effects levels.

Uncertain – Exposures exceed the no-effect level, but risk cannot be quantified because a low-effect level is not available ("U" is used in summary tables).

Some Possible Risk – Exposures exceed no-effect levels but not chronic low-effect level ("C" used in summary tables).

Possible Risk – Exposures exceed chronic effects level but not acute effects level ("B" used in summary tables).

Probable Risk – Exposures represent the highest-level risk that could be quantified ("A" is used in summary tables).

Key

COEC – Chemical of Ecological Concern
COPEC – Chemical of Potential Ecological Concern
RTV – Reference Toxicity Value
HQ – Hazard Quotient
NOEC – No observed effect concentration
NOAEL – No observed adverse effect level
ER-L – Effects range-low
ER-M – Effects range-median
LOEC – Lowest observed effect concentration
LOAEL – Lowest observed adverse effect level

Figure ES-1
Selection of Chemicals of Ecological Concern